A Performance Study of the VDL Mode 3 Subnetwork Aircraft MAC Sublayer Random Access Algorithm

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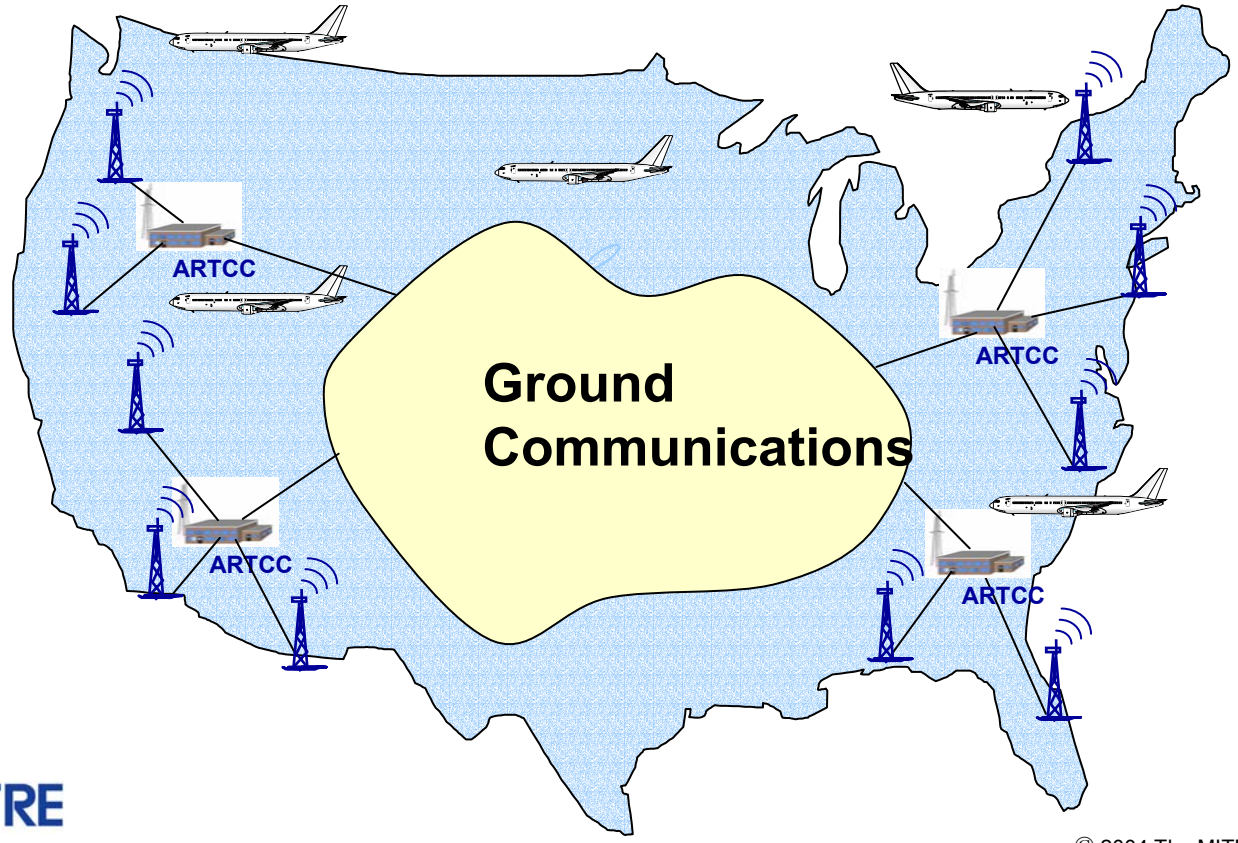
Introduction

- Very High Frequency (VHF) Digital Link (VDL) Mode 3 aircraft use a random access algorithm to make downlink slot reservation requests
- Purpose: determine if the high-priority downlink message end-to-end delays can be improved by modifying the algorithm
- Present preliminary results of the simulations: high-priority downlink message 95th percentile delays

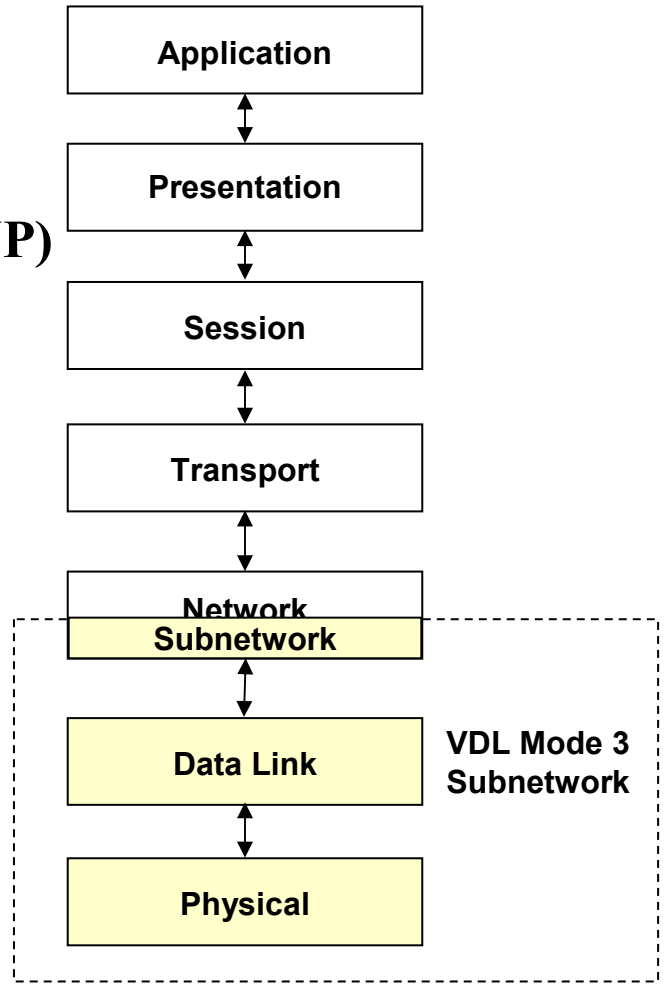
VDL Mode 3: A Ground-Based Air/Ground Communications Subnetwork

- 117.975 – 137 MHz
- 25-kHz Time Division Multiple Access (TDMA) channels

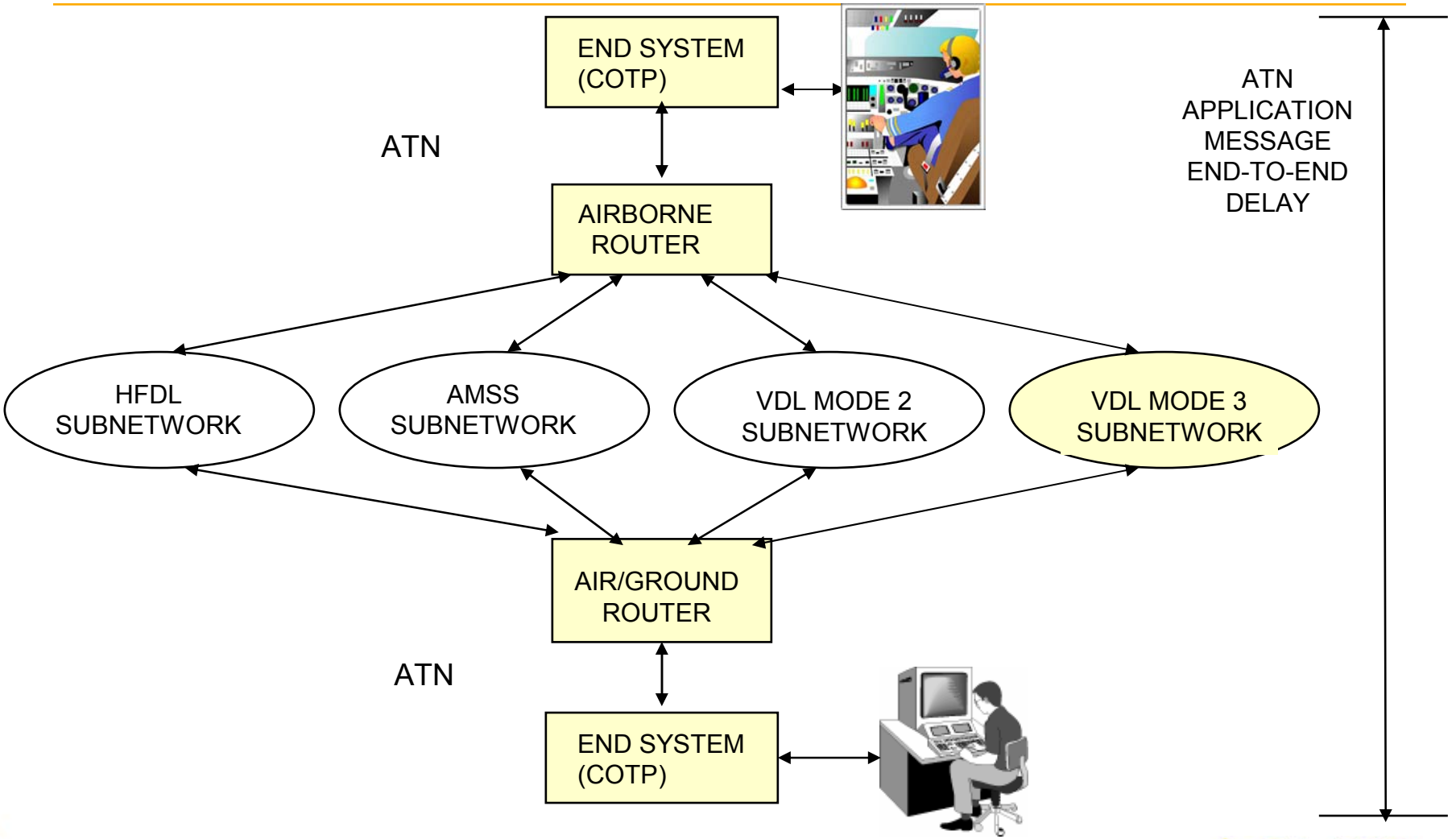


OSI 7-Layer Model and VDL Mode 3 Subnetwork

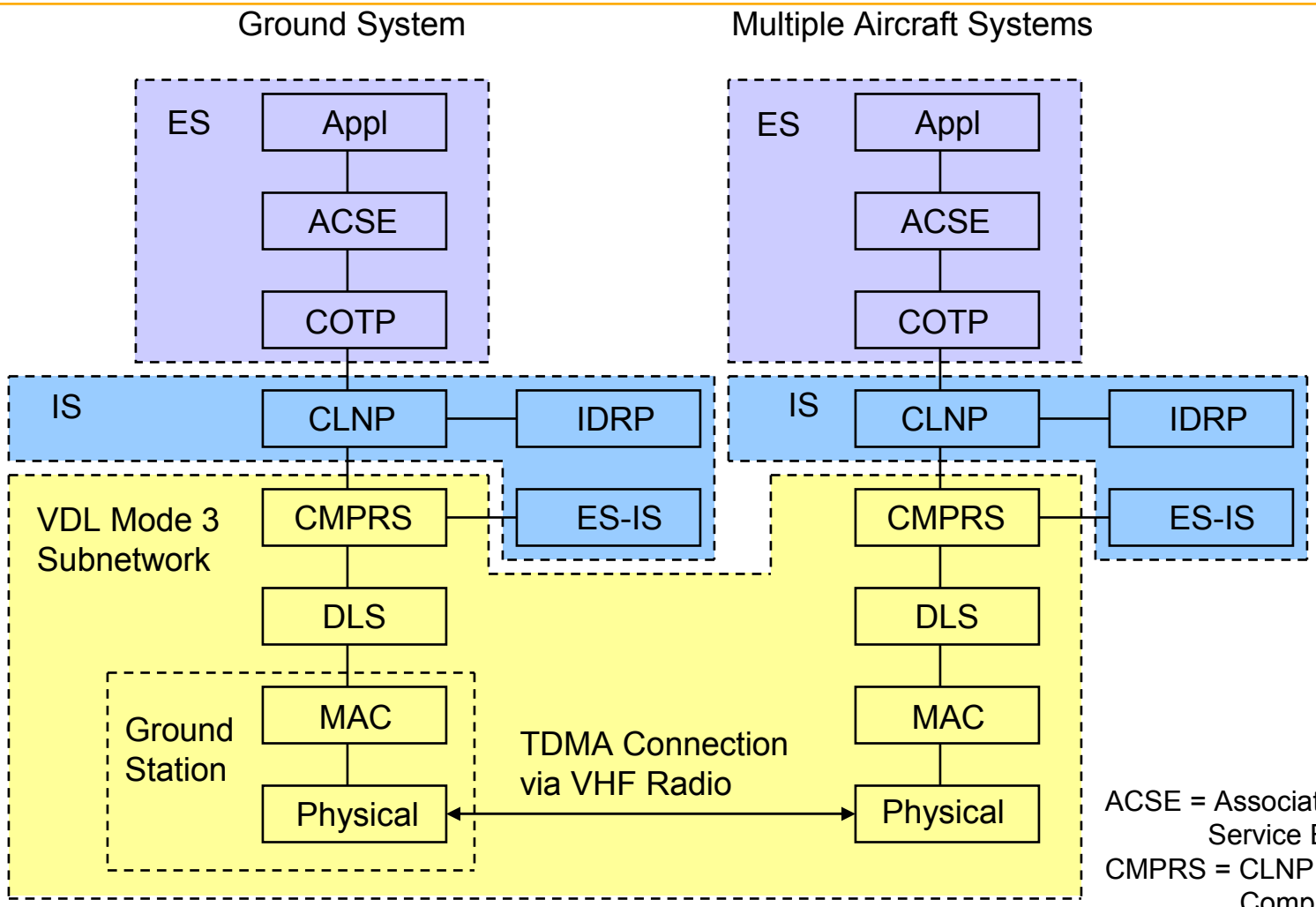
- Subnetwork layer
  - ISO 8208
  - Connectionless Network Protocol (CLNP)
- Data link layer
  - Data Link Service (DLS)
  - Media Access Control (MAC)
    - TDMA
  - Link Management Entity (LME)
- Physical layer
  - D8PSK modulation
  - 31.5 kbps data rate



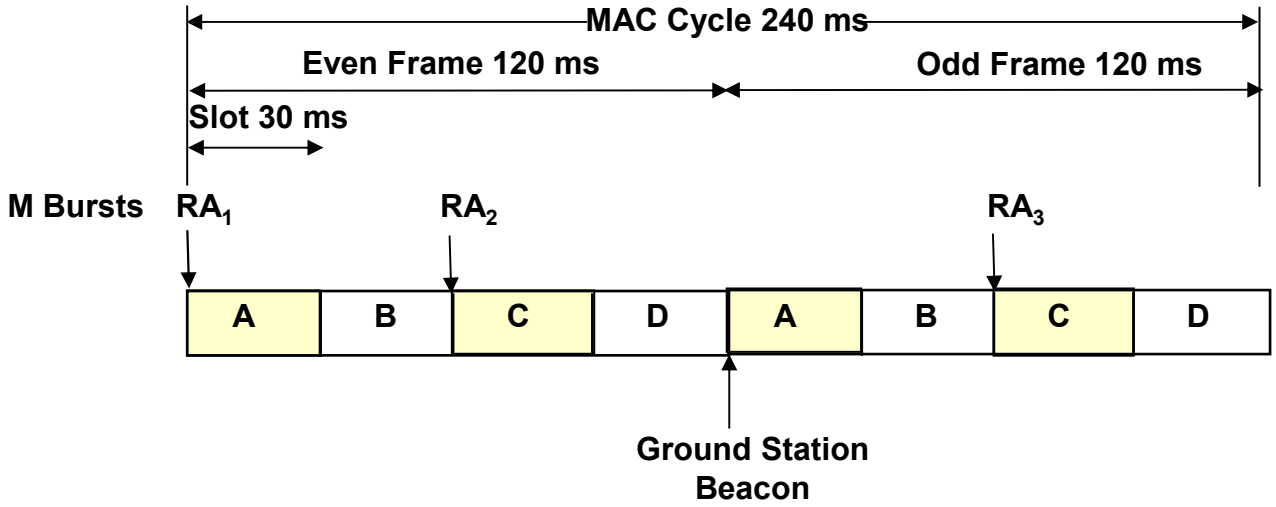
Aeronautical Telecommunication Network (ATN)



An Integrated VDL Mode 3/ATN Model



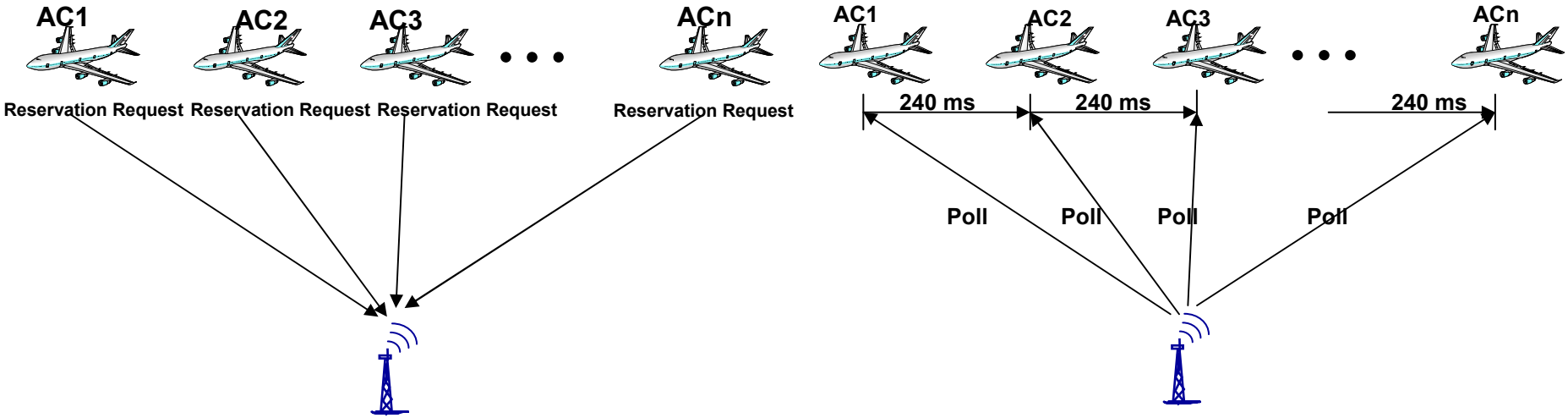
VDL Mode 3 Subnetwork MAC Sublayer Timing and System Configurations



System Configuration	Supported User Groups	Each Group Services to
Discrete Addressed Voice and Data		
2V2D	A: Voice, Voice; B: Data, Data	2	Dedicated Voice and Data

Aircraft Downlink Message Slot Reservation Request

- Downlink slot reservation: a combination of
  - Random access reservation request by aircraft and
  - Poll by ground station



- For random access reservation request: aircraft use *Random Access Downlink M Burst Selection Algorithm for Aircraft Stations*

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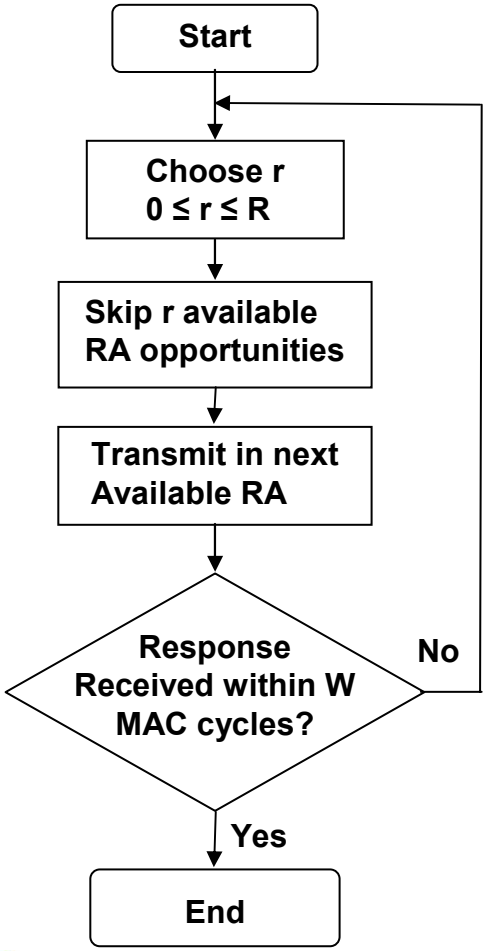
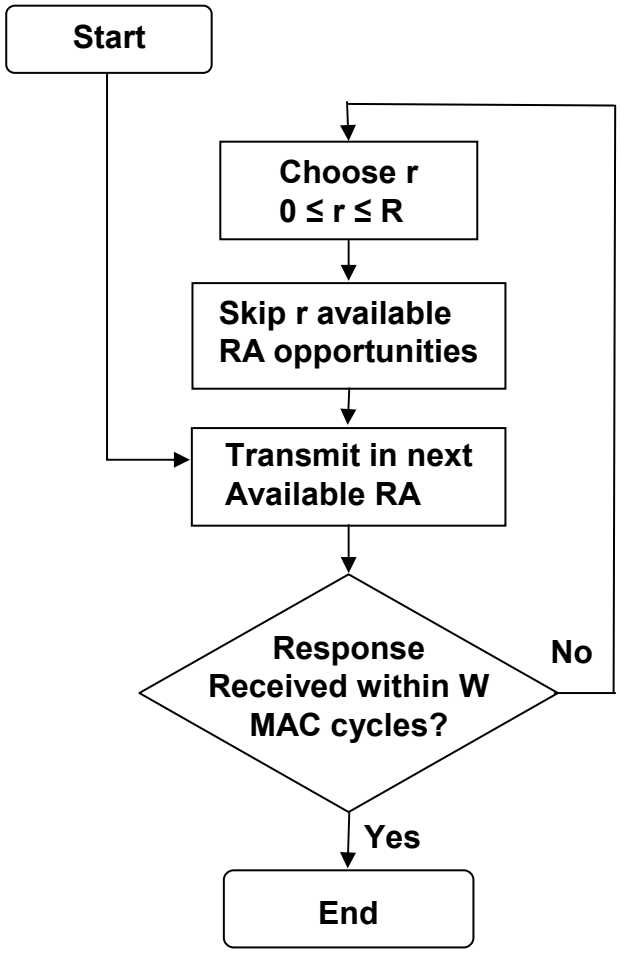
Random Access Downlink M Burst Selection Algorithm for Aircraft Radios

Existing Algorithm



Modified Algorithm



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Modeling and Simulation Methodology

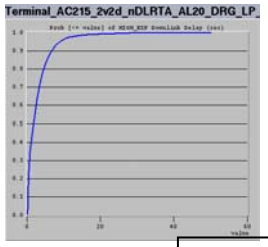
Application Message Traffic Model
LF = 0.2 – 2.0
Random Access Algorithm Parameters
W = 4, R = 16

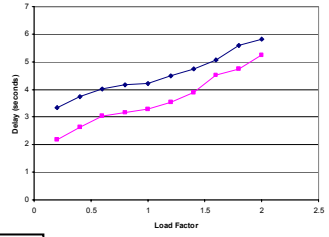
18 AC Model

26 AC Model

34 AC Model

44 AC Model





Data collection and Analysis:
High-priority Downlink message 95th percentile delays

Preparation and Simulation Execution

Analysis

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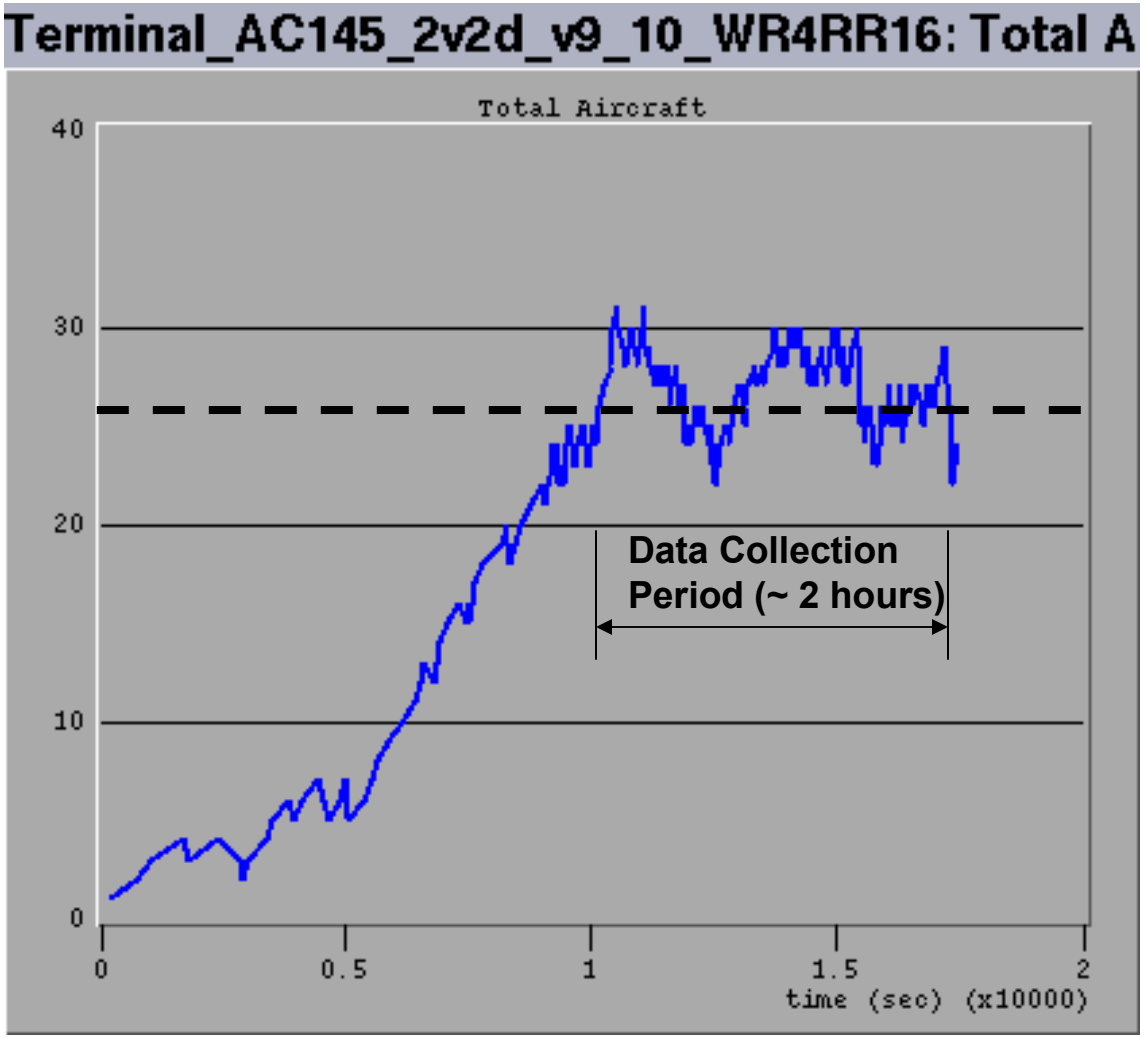
Number of Aircraft During Simulation for the 26 Aircraft Model

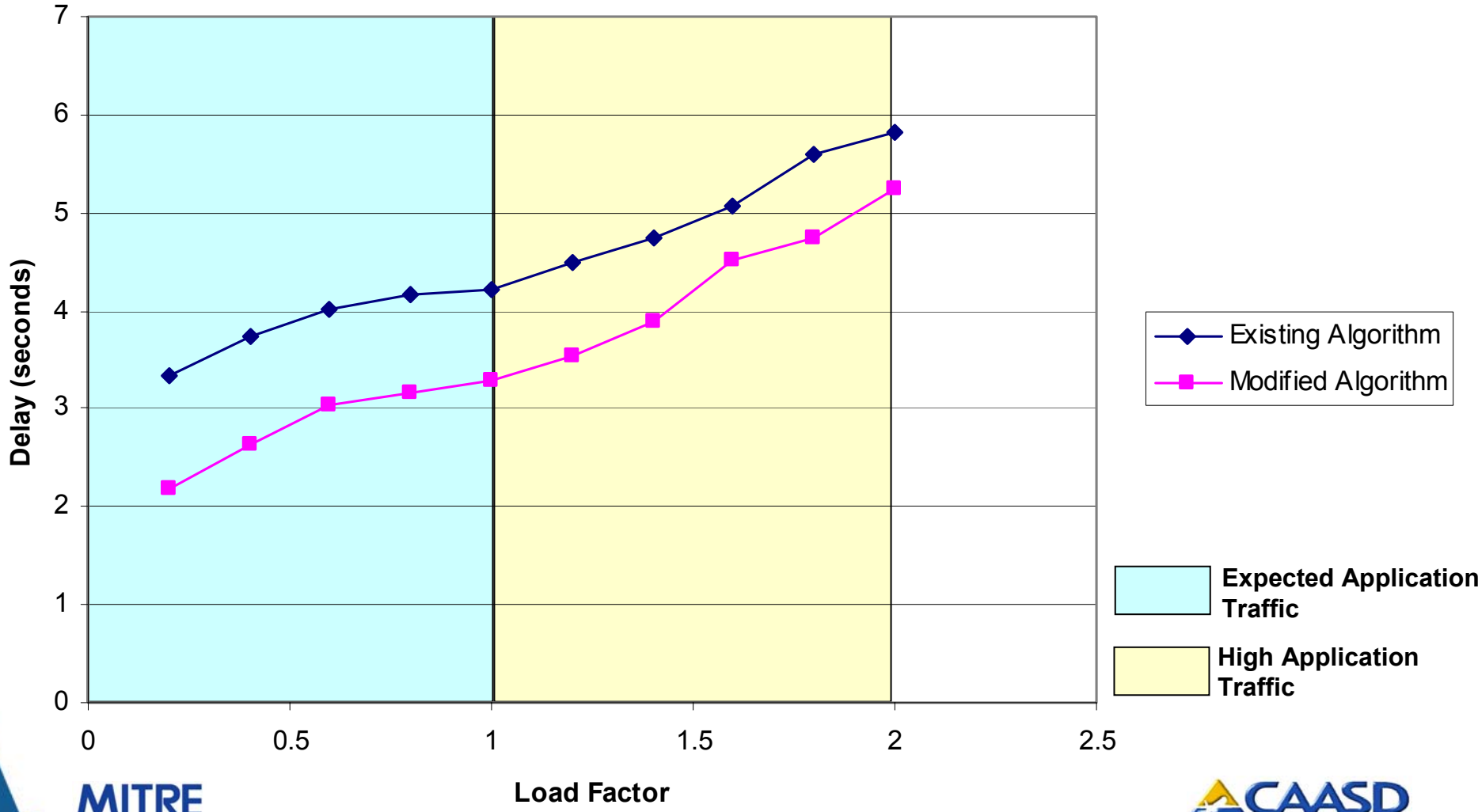


Terminal Domain Application Message Traffic Model

Application Message Distribution	Priority (Note 7)	Uplink (From Ground Station)		Downlink (From Aircraft)	
		Average message rate	Average size in bits	Average message rate	Average size in bits
Exponential inter-arrival with Poisson message size (point-to-point)	High	0.017 (1 msg/min)	137	0.024 (1 msg/42 sec)	110
	Medium	0.0017 (1 msg/10 min)	198	0.0008 (1 msg/20 min)	100
	Low	0.001 (1 msg/17 min)	2400	0.002 (1 msg/10 min)	2400
Constant (Note 4 & 5)	Low	0.017 (1 msg/1 min)	3325	0.0033 (1 msg/5 min)	1760

Notes:
1. Rates are in number of messages per second per aircraft.
2. Each message is acknowledged at the Data Link Sublayer except broadcast.
3. Ack of uplink message uses downlink M subchannels; ack of downlink message required 4 octets conveyed in the V/D (data) subchannels.
4. Uplink broadcast messages are represented by constant uplink messages.
5. Periodic fixed size downlink meteorological observations.
6. All traffic collectively represents a Load Factor of 1.
7. Each priority has its own COTP connection except for broadcast messages.

High-Priority Message Downlink 95th Percentile End-to-End Delay for 18 Aircraft



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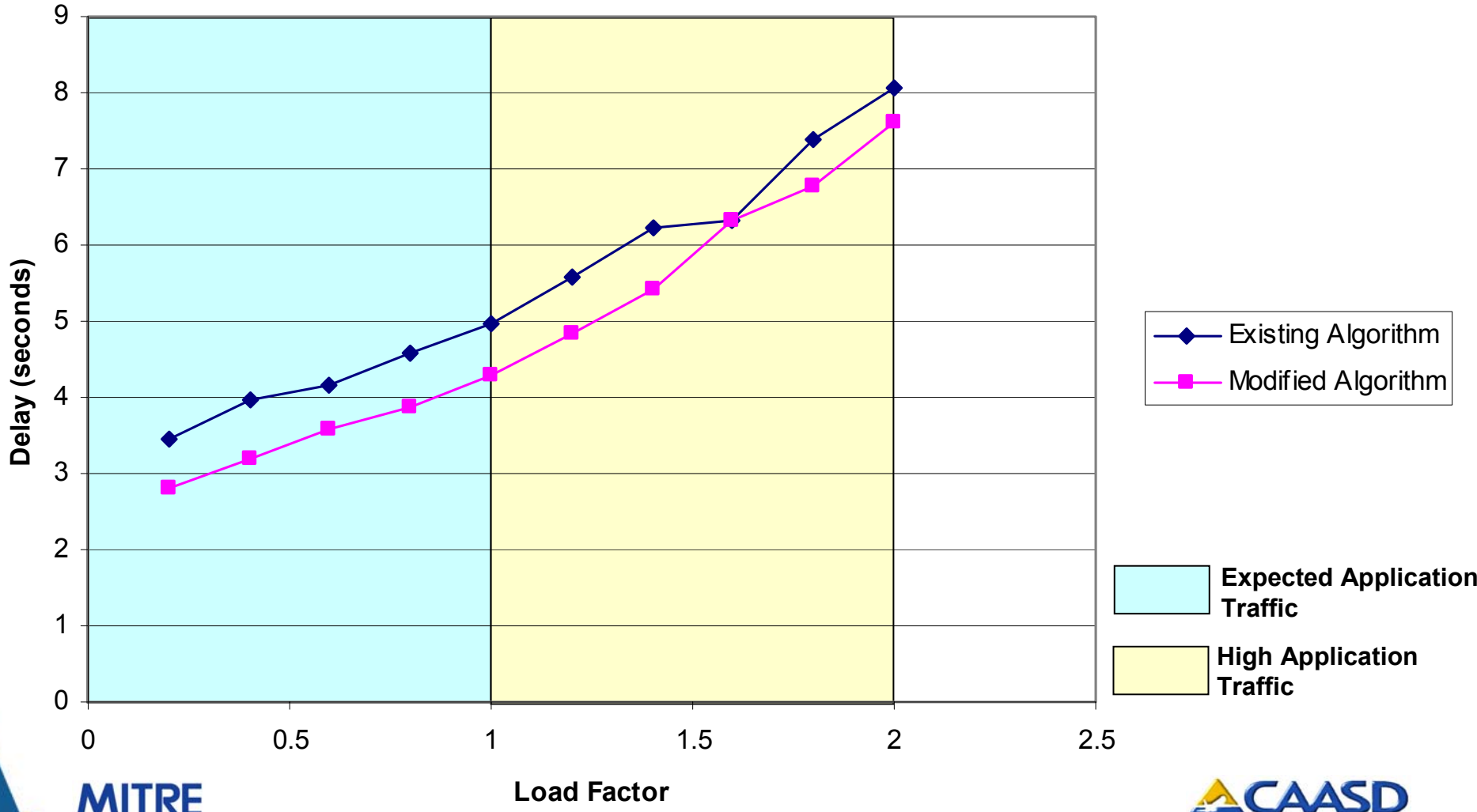
High-Priority Message Downlink 95th Percentile End-to-End Delay for 26 Aircraft



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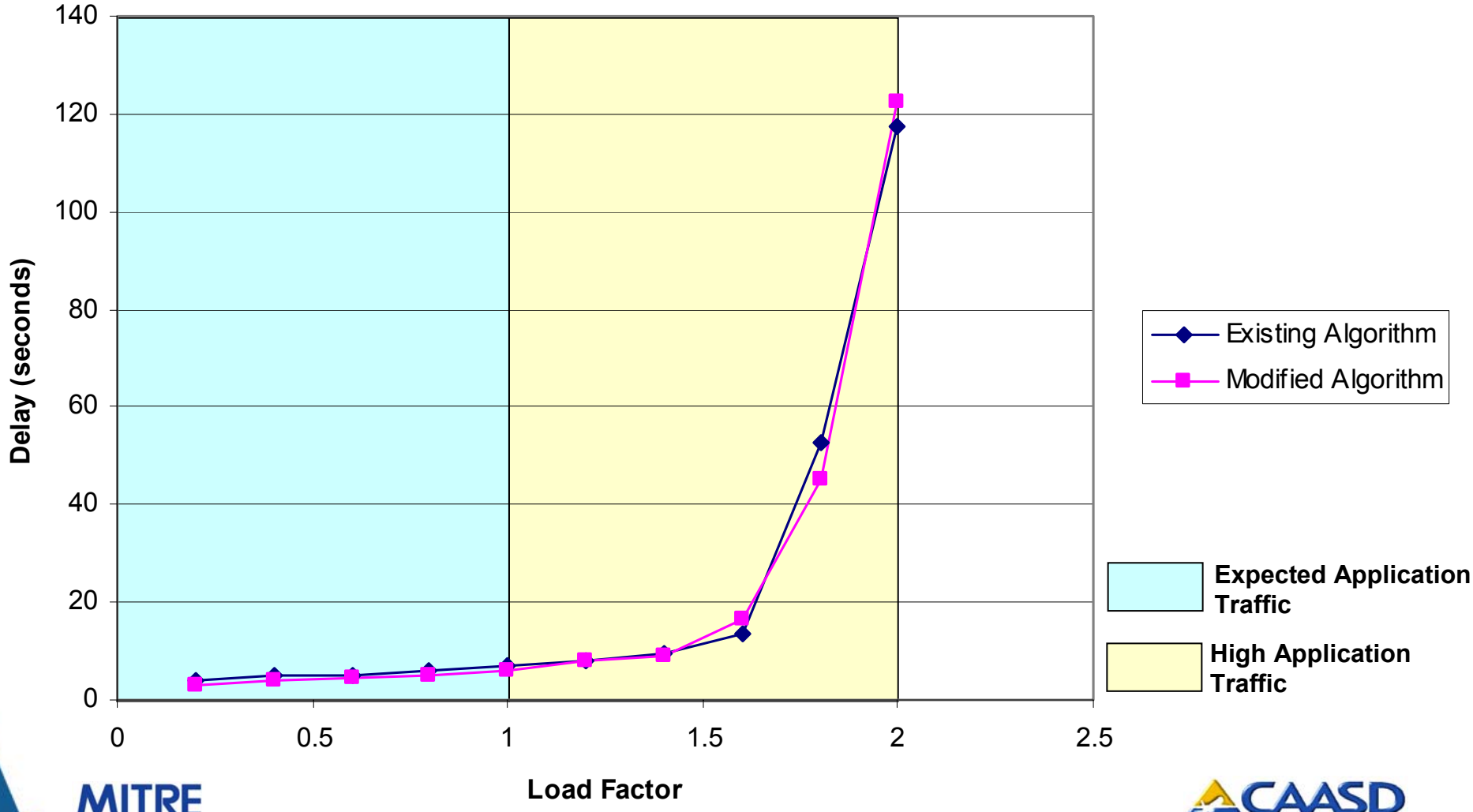
High-Priority Message Downlink 95th Percentile End-to-End Delay for 34 Aircraft



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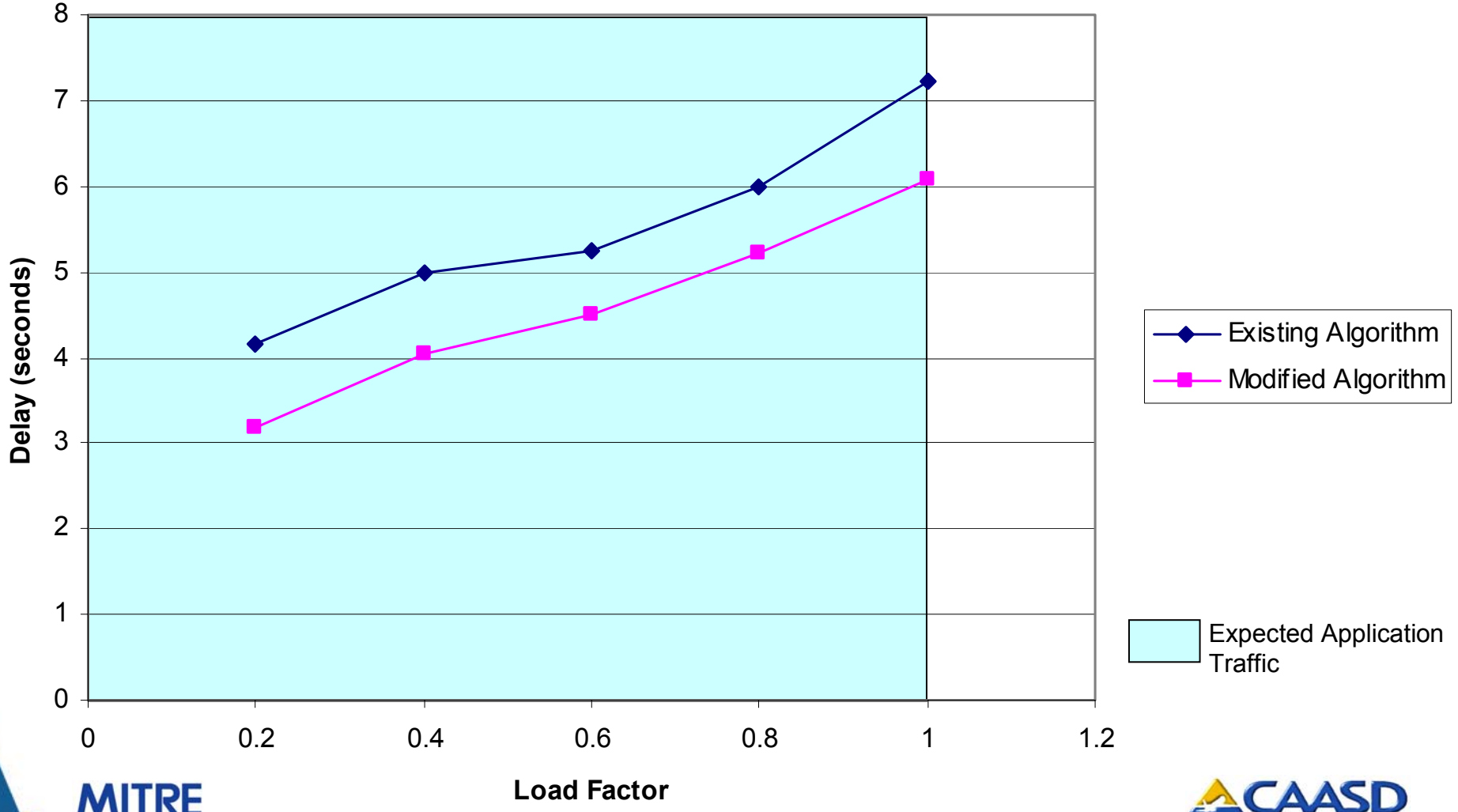
High-Priority Message 95th Percentile End-to-End Delays for 34 Aircraft



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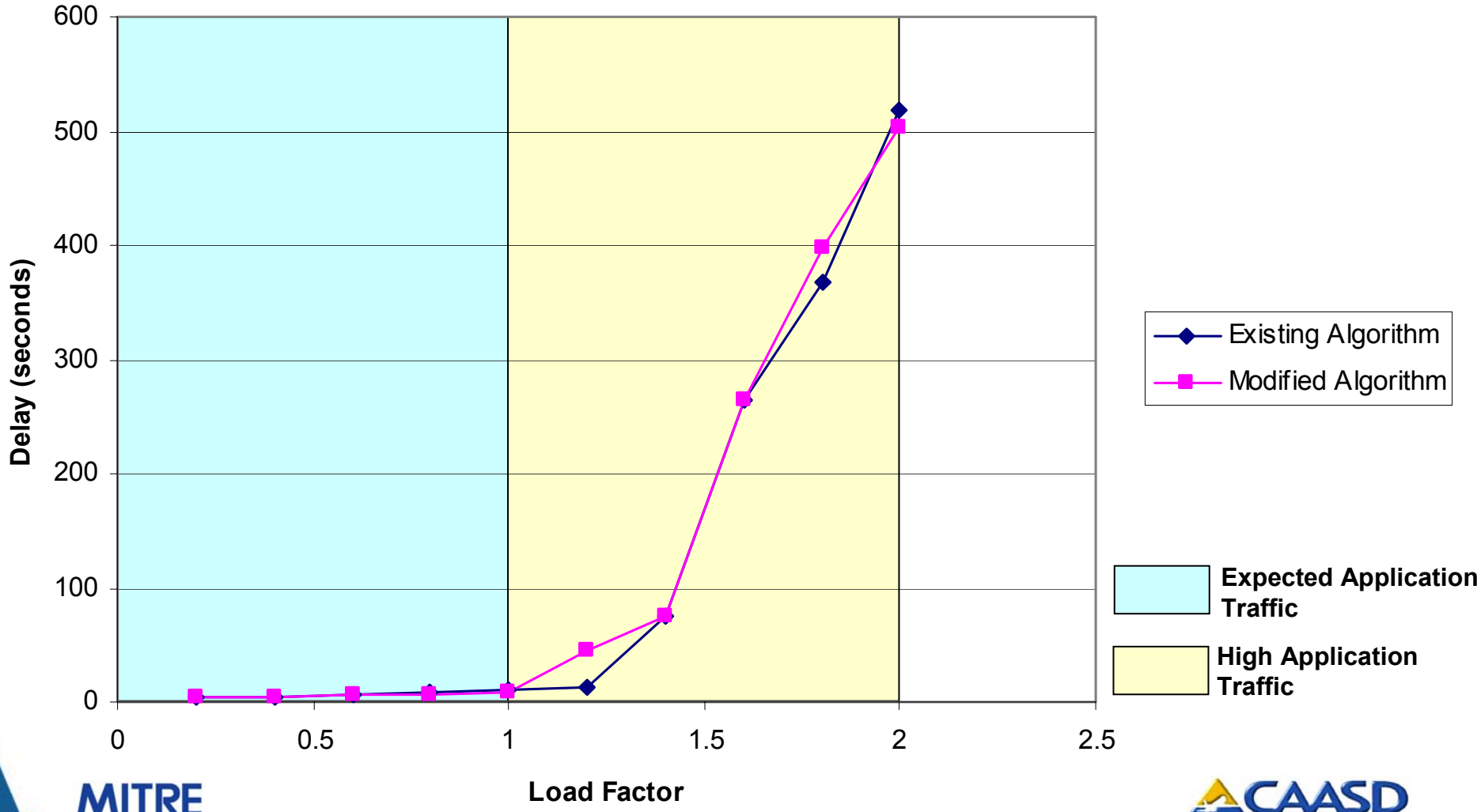
High-Priority Message Downlink 95th Percentile End-to-End Delay for 44 Aircraft



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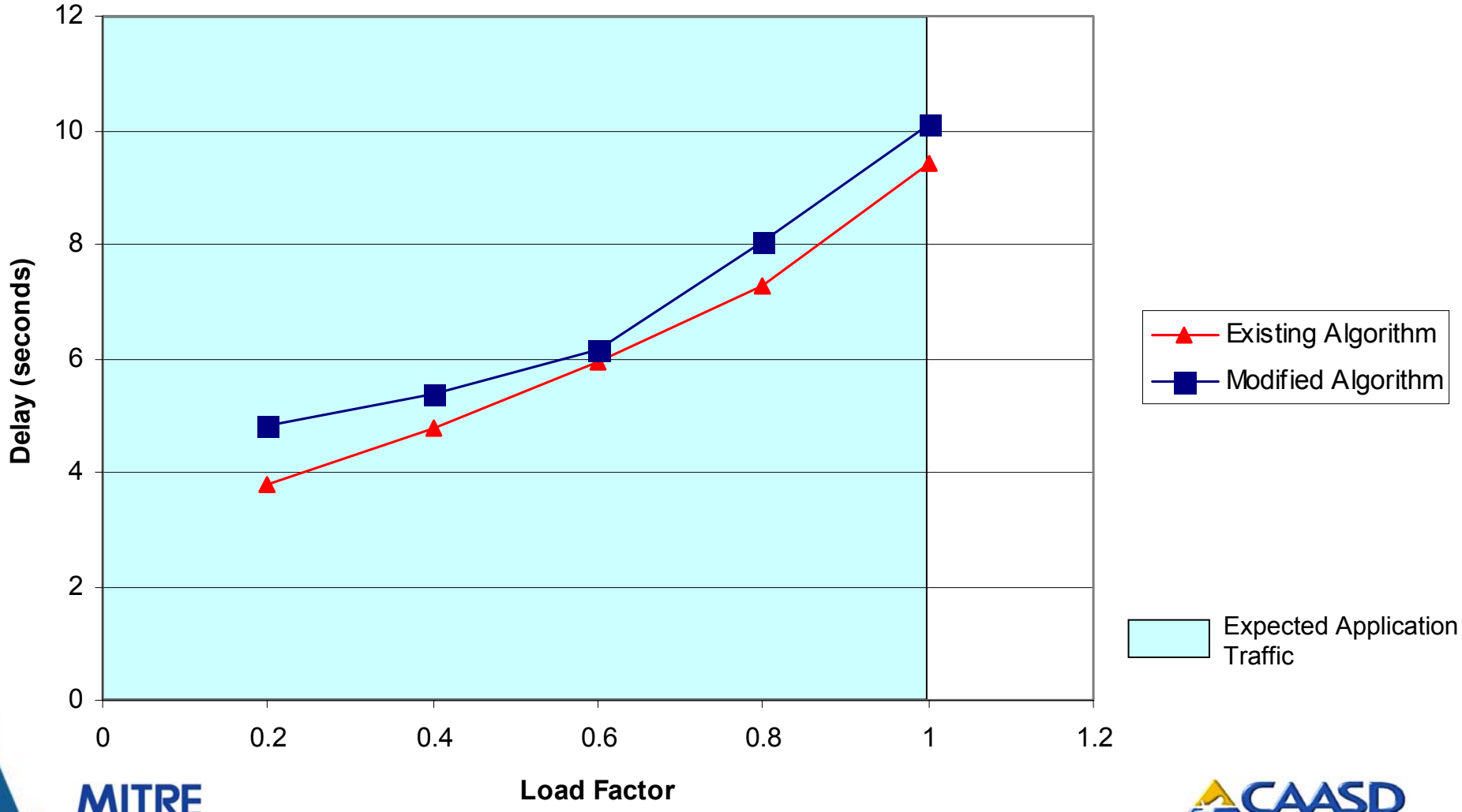
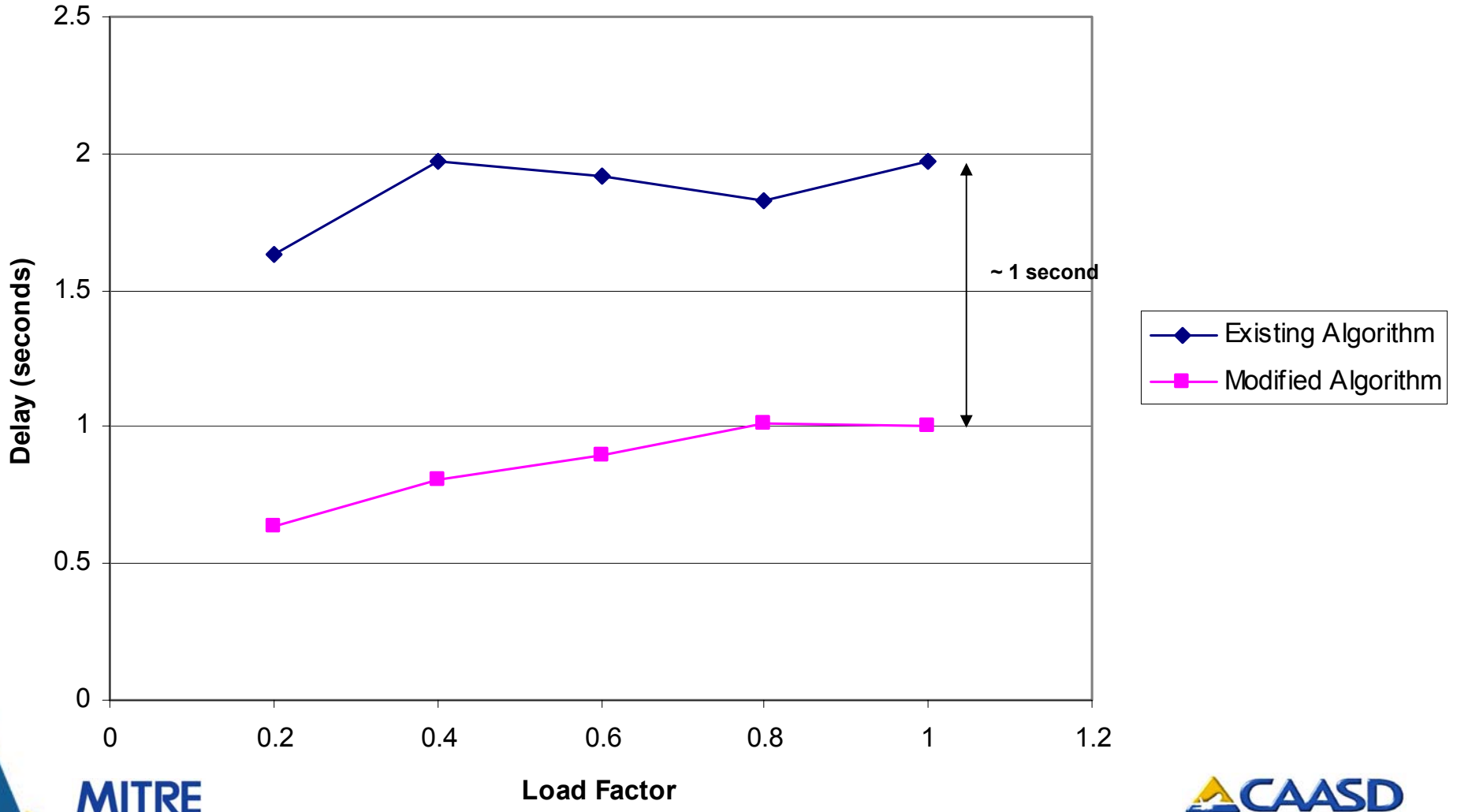
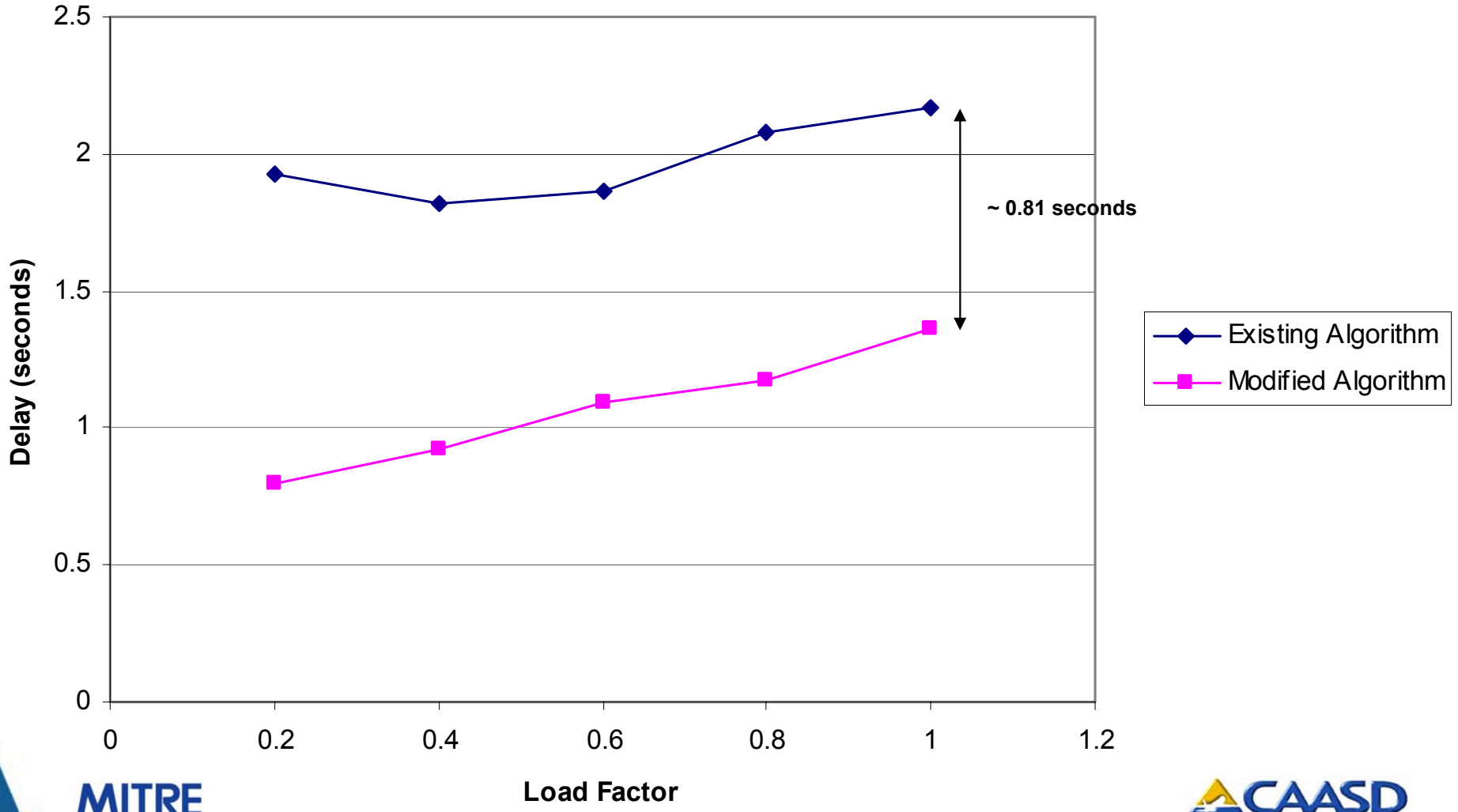


High-Priority Message Mean End-to-End Delays for 18 Aircraft



High-Priority Message Mean End-to-End Delays for 26 Aircraft



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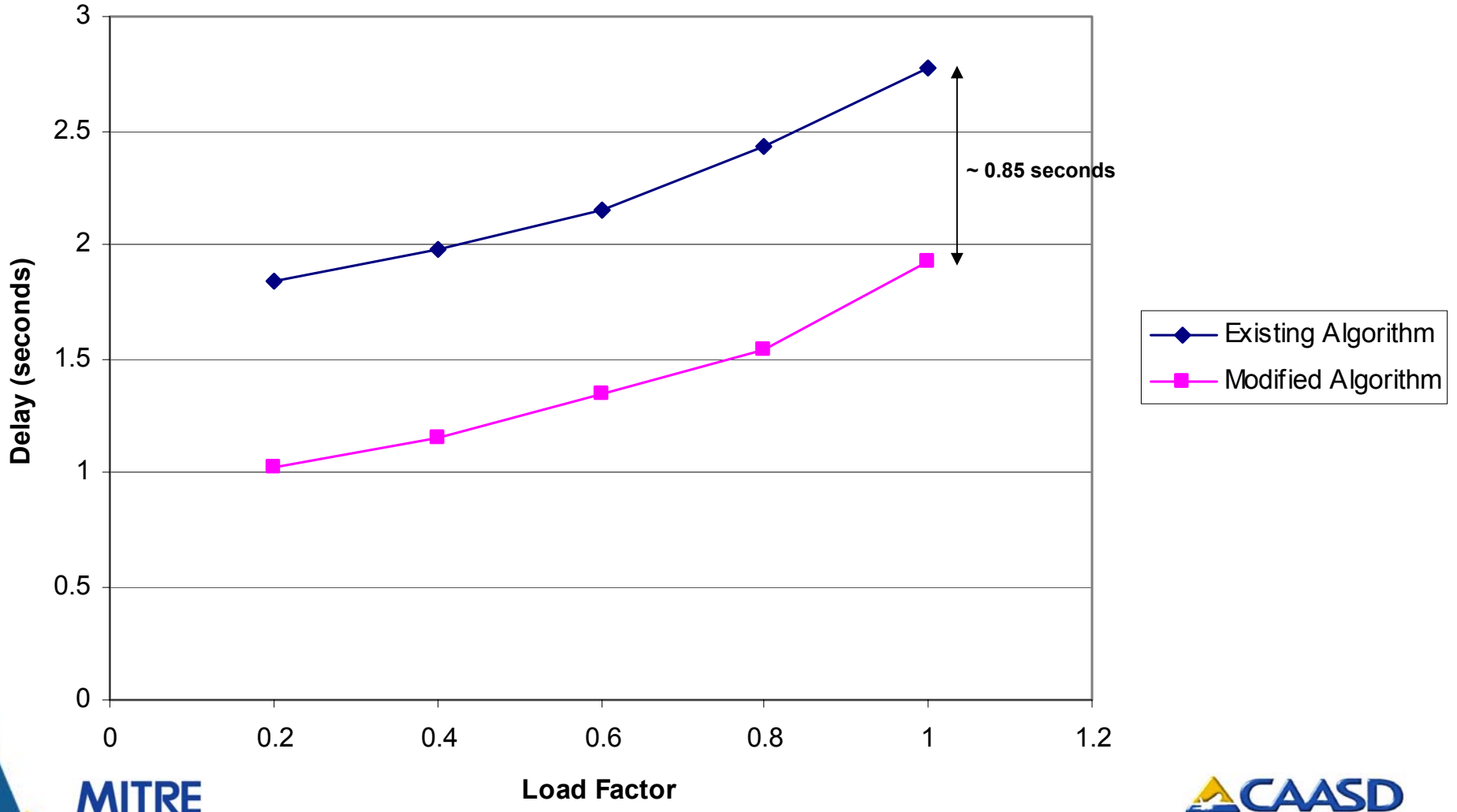

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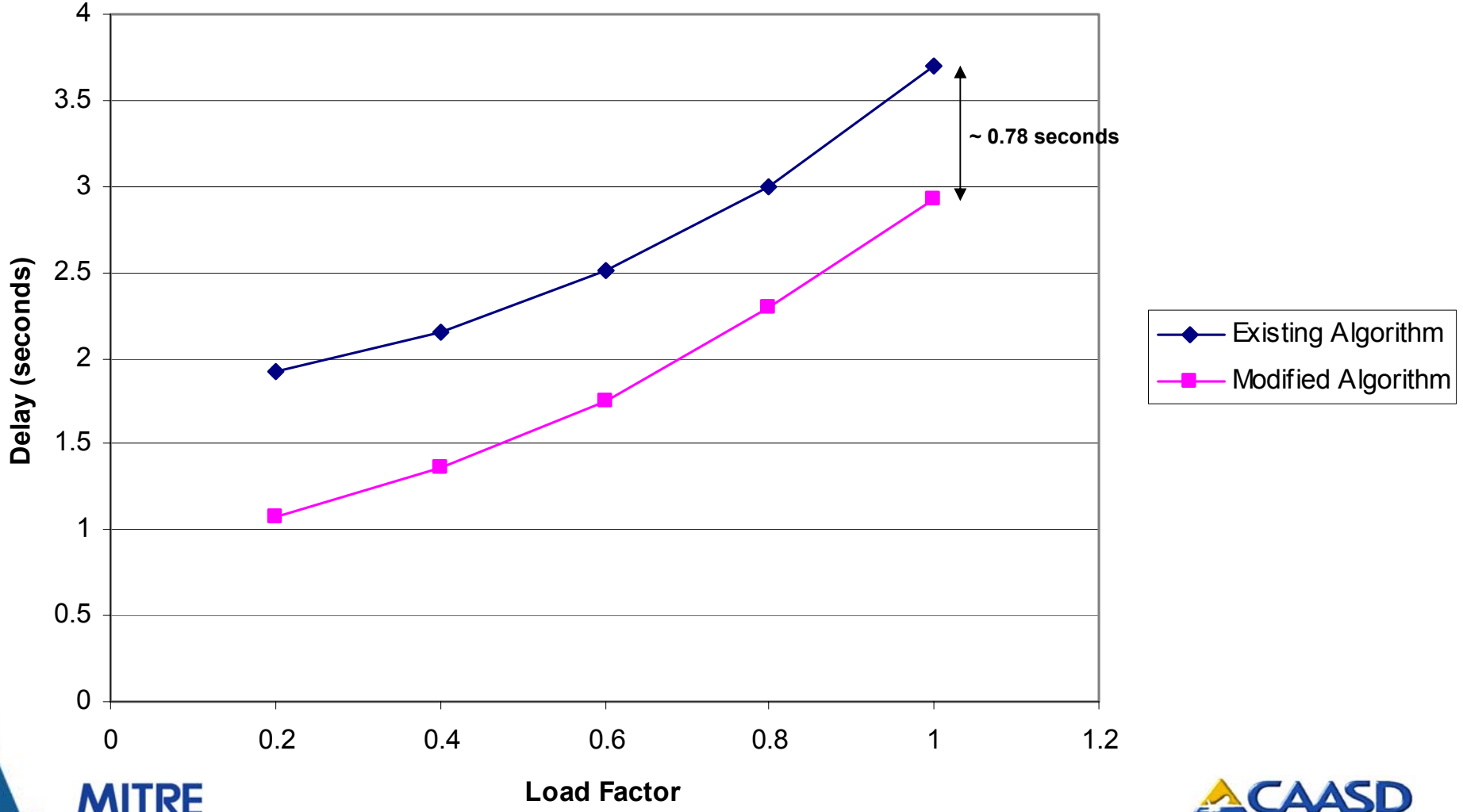

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Summary

- **High-priority downlink end-to-end delays can be improved significantly by modifying the existing random access downlink M burst selection algorithm**
- **Backward compatible**
  - **Modified algorithm can coexist with the existing algorithm**